



Citation for published version:

Morley, B 2010 'Environmental Policy and Economic Growth: Empirical Evidence from Europe' Bath Economics Research Working Papers, no. 12/10, Department of Economics, University of Bath, Bath, U. K.

Publication date:

2010

Document Version

Publisher's PDF, also known as Version of record

[Link to publication](#)

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Environmental Policy and Economic Growth: Empirical Evidence
from Europe

Bruce Morley

No. 12/10

BATH ECONOMICS RESEARCH PAPERS

Department of Economics



Environmental policy and economic growth: Empirical evidence from Europe

By

Bruce Morley^{*}

Department of Economics

The University of Bath

Bath, UK

Abstract

The aim of this study is to determine whether environmental policies affect economic growth. Using a standard model of economic growth and a panel of European data, there is evidence that environmental taxes have had a negative effect on economic growth over the last ten years, indicating the ‘double dividend’ does not hold. This effect is particularly evident when other distortionary taxes are included in the model. A second contribution of this study is to incorporate the complimentary measure of renewable energy provision into the model. Again the results indicate a negative relationship between renewable energy and economic growth, offering support for the curse of natural resources.

Keywords: Environmental policy, economic growth, renewable energy, natural resources.

JEL.: H23, Q43.

^{*} Address for correspondence: Department of Economics, University of Bath, Bath, BA2 7AY, UK. E-mail: bm232@bath.ac.uk, Tel. + 44 (0)1225 386497, Fax: + 44 (0)1225 384323.

1. Introduction

Following recent international agreements over the need to reduce greenhouse gases, such as the G8 statement that it aims to cut emissions by 50% before 2050, the means of achieving these cuts is becoming ever more important. The two most commonly used policies have involved the use of environmental taxes and the expansion of renewable energy production. This has generated a debate over the repercussions of increased environmental taxes with regard to the wider economy, with some groups arguing for a double dividend from the increased taxes, as the revenue could be used to reduce other distortionary taxes, so increasing economic growth. The aim of this study is to contribute to the debate over the effects of environmental taxation on the wider economy and whether the much debated double dividend occurs in Europe. In addition a second contribution to the literature relates to the effects of renewable energy on economic growth, partly to proxy fiscal expenditure on the environment and also to determine if the curse of natural resources holds with renewable energy as it can with non-renewable energy resources. Finally political factors, such as determining if transition economies have a different relationship are considered.

As noted by Brock and Taylor (2005) there is only limited empirical evidence on the nature of the relationship between environmental policy and economic growth¹. This is largely due to limitations in environmental data, especially data relating to environmental taxes and renewable energy. However since the 1990s, the European

¹ Although this is true in the context of growth models, there is an extensive literature assessing the effects of per capita growth on pollution and the existence of an environmental Kuznets curve following the original study by Grossman and Krueger (1995).

Union (EU) has conducted a process of environmental tax reform (ETR) and encouraged the use of renewable energy resources, the data produced as a result of both policies has been employed in this study. With regard to ETR, the emphasis has been on revenue neutral taxation, such that the extra revenue from environmental taxes could be used to reduce other taxes, in particular labour and capital taxes which are argued to have a distortionary effect on economic growth and therefore producing the double dividend.

So far much of the literature has concentrated on the use of theoretical models to determine the effects of environmental taxes on both the environment and the economy, as well as the use of simulation studies to predict the effects of ETR, as far as it is known, no econometric models have been used to date. The results provide little evidence of a double dividend², as in the majority of cases there is no benefit to the wider economy in terms of increased growth, but the results depend on the pre-existing tax structure. For instance Goulder (1995) finds that modelling environmental tax effects, excluding pre-existing taxes, tends to understate the cost of the new tax. In addition models developed by Brock and Taylor (2005) produce evidence of the policies to improve the environment creating a drag on growth rates.

Since the development of endogenous growth models, there have been a number of studies that have indicated an important role for taxation and other fiscal measures as

² The double dividend refers to an increase in environmental taxes reducing levels of emissions as well as increasing economic growth. The evidence to date suggests the initial aspect of the double dividend occurs, with a reduction in pollution as taxes rise, however as Bosquet (2000) indicates, there is less evidence overall, mostly using simulations, to support the second part.

determinants of the steady state growth rate. The original work in this area was by Barro (1990), who suggested that the effects of fiscal policy on economic growth depends on whether the government expenditure is for consumption or investment purposes and whether tax is distortionary or non-distortionary. In general it is assumed distortionary taxes relate to those taxes that affect savings or investment decisions, such as taxes on capital, whereas consumption taxes are non-distortionary. The empirical literature has tended to support the Barro (1990) model, such as Barro (1991), who shows that government consumption has a negative effect on economic growth and both Kneller et al (1999) and Lee and Gordon (2005), who show that distortionary taxes reduce growth.

This study attempts to determine the nature of the relationship between environmental taxes, renewable energy and economic growth, whilst accounting for the effects of other taxes. A panel data approach is used covering most EU countries and Norway from 1995 to 2005, including the transition countries that have recently joined the EU. The political factors affecting this relationship are also considered, in particular the importance of Scandinavian countries, who have been among the most enthusiastic supporters of policies to protect the environment. The study however fails to find support for the double dividend in Europe suggesting environmental taxes are distortionary and also finds evidence that renewable energy has a negative effect on growth.

After the introduction the background theory and methodology are discussed. Following this we describe the data and interpret the results and finally we offer some conclusions and policy implications of this study.

2. Model and Methodology

The model follows the conventional approach to modelling economic growth, in which the standard conditioning variables are incorporated along side the environmental tax, renewable energy and distortionary tax variables³.

This produces the following specification:

$$\Delta y_{it} = \alpha_0 + \alpha_1 \Delta k_{it} + \alpha_2 \Delta twf_{it} + \alpha_3 iny_i + \alpha_4 tax_{it} + \alpha_5 re_{it} + \alpha_6 D_{it} + u_{it} \quad (1)$$

Where Δy_{it} , Δk_{it} and Δtwf_{it} are per capita real GDP growth, per capita real fixed capital formation growth (investment) and the total working population growth respectively and act as the conditioning variables. The iny_i represents the initial level of real per capita GDP in each country and measures convergence over the specified time span. Tax_{it} represents the environmental taxes and in latter models also capital and labour taxes, all of which are measured as a percentage of GDP. Re_{it} is renewable energy, measured as the amount of electricity generated from renewable sources as a percentage of total electricity consumed. D_{it} are dummy variables reflecting political

³ In addition to the first three variables, there have been numerous other explanatory variables included in economic growth models, such as human capital, export measures, FDI measures and political measures such as corruption, although the evidence on their effects is mixed and tends to be country specific. With respect to human capital, there was a lack of data on education levels for some countries in this sample, especially the transition economies. It has therefore been omitted from this model, as has been the case with other similar studies, such as Kneller *et al.* (1999).

changes in the EU and u_{it} is a Gaussian error term. All variables are in logarithms except tax_{it} and re_{it} which are in percentage form.

As has been noted by Goulder (1995) and Bovenberg and Goulder (1996) among others, it is important to incorporate the effects of other non-environmental taxes into the model, especially distortionary taxes. To do this we respecify the model to include specific measures of both labour tax revenues and capital tax revenues, all of which are measured relative to GDP. These two specific measures are used as they are the main distortionary forms of taxation, hence according to the ‘double dividend’ approach, any rise in environmental taxes should facilitate a reduction in these taxes.

To compliment the effects of environmental taxes in the specification, some measure or proxy of public expenditure on the environment is also required in this type of specification, as suggested by Kneller *et al.* (1999). The re_{it} variable should partially reflect the level of fiscal resources being directed at measures to improve the environment by encouraging renewable energy usage in each country, as most European countries use subsidies to encourage the sourcing of energy through the renewable sector (Blok, 2004). Tahvonen and Salo (2001) have studied the theoretical relationships between renewable energy and economic growth, in the context of a model including non-renewable resources. They found the relationship depended on whether the assumption of technical change was included, so that in the presence of technical change, increased use of renewable energy resources leads to an initial increase in GDP growth. However there is an alternative interpretation of the relationship between energy resources and economic growth that is well established in the literature and known as the curse of natural resources (Sachs and Warner, 2001).

Although public expenditure is an important factor in determining levels of renewable energy, the country specific environment should also have an effect, as renewable energy tends to rely on rainfall, wind, mountainous terrain and other natural phenomenon. So those countries rich in these ‘natural resources’ should have greater access to the means of producing renewable energy.

The final set of explanatory variables relate to important political factors that have affected both the EU’s economic and environmental policy. These are basic dummy variables representing the Scandinavian countries, who have been instrumental in encouraging the adoption of policies aimed at benefitting the environment, having been the first to introduce environmental taxes in the early 1990s. The transition economies that have recently joined the EU are also modelled with dummy variables, as the data spans the era when they were preparing to join the EU and satisfy its environmental requirements and also when most of them subsequently joined in 2004.

As in the conventional literature on growth models, we assume, both investment and the work force should have a positive effect on growth. Investment is included in the model, as Mankiw *et al.* (1992) argue it represents the level of savings, which they argue increases growth as savings rise. The sign of the environmental taxes and renewable energy variables is less certain. If the double dividend is apparent, then there should be a positive sign on the environmental tax variables, as a rise in these taxes, leads to a consequent fall in distortionary taxes and therefore a rise in economic growth. However if environmental taxes are themselves acting as a further distortionary tax, then the sign could be negative. Fullerton *et al.* (2008) discuss some of the theoretical reasons for rejecting the double dividend, for instance it is possible

that the environmental tax has its own specific distorting effects on the supply of labour, producing a greater distortion than the labour tax itself. The sign on the renewable energy variable is an empirical matter, depending on the extent of any technological spillovers. Finally when the other distortionary taxes are added to the model, it is assumed the signs will be negative for both labour and capital taxes, as found by Lee and Gordon (2005).

Environmental tax revenue as a proportion of GDP is used as a proxy for the tax rate in the following tests. The measure of environmental tax revenue is based on the internationally recognised definition used by the Statistical Office of the European Union (Eurostat) and accepted by the main international bodies, such as the Organisation for Economic Co-operation and Development (OECD). An environmental tax is defined as any tax, which has a physical unit as a base and for which there is evidence that it has a specific effect on the environment⁴. The data on environmental tax revenue is predominantly comprised of taxes on energy products, such as the duty charged on hydrocarbons in the transport sector, as well as the industrial sector. It also includes the fossil fuel levy, which is a tax on electricity generated using fossil fuels. A recently introduced tax is the climate change levy,

⁴ Some studies have questioned the effectiveness of environmental taxes in the EU. Ekins and Speck (1999) and Bohringer and Rutherford (1997) have noted that many countries introduced exemptions for some sectors of industry to prevent a loss of competitiveness. Other studies such as Fredrikson (1999) have reviewed the effectiveness of pollution taxes in the context of pollution abatement and political lobbying. The EU recently changed its approach to environmental taxes, due to many countries fears over the loss of competitiveness, allowing a greater role for countries to implement their own policies. A discussion of the implications of the policies is beyond the scope of this study, but set out in the European Commission paper (2005).

including petroleum, gas, coal and electricity. Further related tax sources include vehicle excise duty, the VAT applied to petroleum and the air passenger duty, which applies to air travel within the European Economic Area (EEA), but at a lower rate with countries outside the EEA. The other main sources of environmental tax revenue relate to the mining and quarrying industries, landfill and the aggregates levy.

3. Data and Results

The data is all annual and runs from 1995 to 2005 and includes all the economies that are currently members of the EU⁵ and for which there is data, including those that joined the EU recently such as the transition economies (The list of countries is included in Table 1). Norway is also included in the panel despite not being a member of the EU, because along with the other Scandinavian countries it has been in the vanguard of those countries implementing policies aimed at benefiting the environment. Although the data covers the era when some countries were not direct members of the EU, they were preparing to join and trying to conform to the more environmentally friendly policies that the EU encouraged over the sample period.

⁵ The EU data is used due to the recent availability of its environmental tax data and the extensive literature on environmental tax policy in the EU. In addition the definitions of both tax revenue and the renewable energy are roughly common across the EU countries in the sample, ensuring the data shares the same features across the variables in the panel. However the data only starts in 1995 for many of the countries in the sample, limiting the dataset. Where data was missing, as with Malta's GDP, it was sourced from the *International Financial Statistics* (IFS, IMF). The data was taken from the *Economic and Social Data Services (ESDS)* website, which contains the *Eurostat* and *IFS* databases.

The data is taken from the *Statistics Office of the European Communities (Eurostat)* and includes real per capita GDP, fixed capital formation, the total labour force and environmental tax revenue relative to GDP. The labour force consists of the population in each country between the ages of 15 and 65. The renewable energy measure is defined as the percentage of electricity generated using renewable sources relative to total electricity consumed and distortionary taxes comprise labour and capital taxes, as defined by *Eurostat*.

Table 1 provides the summary tax and renewable energy statistics for each individual country. The tax revenue statistics suggest that most countries collect about 3% of GDP in environmental taxes, with the Scandinavian countries having the highest mean, whilst the transition countries have the lowest. With respect to total tax revenue collected⁶, to illustrate the country's tax structure, the amounts collected are about 8%, with again the Scandinavian countries being highest. There is substantially more variation in the renewable energy statistics relative to the tax measures. The lowest are Cyprus and Malta, who produce no electricity using renewable energy, whereas the highest is Norway, with a strong environmental agenda and propitious conditions for renewable energy production, which produces over 100% of its electricity needs from renewable resources. The higher variance, reflects the unpredictability of this source of energy, being dependent on the natural environment. The Scandinavian countries on the whole have higher levels of renewable energy, reflecting national commitments to the environment. And also partially reflecting there availability of renewable energy resources, in terms of rainfall and landscape.

⁶ The tests were also carried out with tax revenue as a percentage of total tax revenue, however the results were not as good as those relative to GDP. Results are available from the authors on request.

One potential problem encountered in the empirical literature on growth models is the short-run influence of the business cycle. The main way to overcome this problem has been to group the data into 5-year observations, where the data is either following a 5 yearly average or the initial value in the five year observation is used⁷. The main problem though with the former approach is that it severely restricts the sample size, which given the limited data availability for environmental taxes is a problem. To maximise the sample size the approach adopted here has been to use the initial value for every five years of data. With eleven years of data available in total, that gives three time series observations for every country, whereas averaging would limit it to just two. The approach used here follows that of Lee and Gordon (2005), who use the initial year of each observation of annualised per capita growth of GDP.

All models are estimated using cross section random effects to account for any individual effects that such a disparate set of countries is liable to experience. This is suggested partly by the nature of the data set and also by the Hausman test statistic of 3.945 for the first set of results, which indicates acceptance of the null hypothesis that random effects are consistent and efficient, whereas fixed effects are inefficient. As the data set has a short time series and relatively long cross section component, this usually suggests random effects are the better option and also why the random effects

⁷ Other studies of economic growth have ignored the short-run effects of the business cycle and included all the observations, such as De Mello (1999). However recent studies on taxes and growth have accounted for the business cycle effects, such as Gordon and Lee (2005) and Kneller *et al.* (1999). For comparison the models were also estimated with the total observations and five year differences, with the negative tax and renewable energy effects also being evident.

are limited to the cross section. In addition Whites adjusted standard errors are applied to the cross section to account for the heteroskedasticity.

Table 2. contains results from the basic growth models, incorporating the control variables and environmental tax relative to GDP variable. The result suggests that as usual investment is a highly significant and positive determinant of growth, with a 1% rise in investment producing a 0.17% increase in growth, although the growth in the labour force is insignificant. This could be due to the very stable nature of the labour force across the EU, relative to that in developing economies. The initial GDP term is negative and significant, indicating convergence across the EU countries in the sample. The environmental tax variable is insignificant, which suggests the ‘double dividend’ does not feature in the EU. The dummy variable representing the Scandinavian economies in column (2) is not significant in these first tests, whilst adding the dummy variable for the formerly centrally-planned transition economies suggests a significant difference in their growth rates. In this latter model, the initial GDP variable becomes insignificant, indicating the transition economies are responsible for much of the convergence across Europe.

The final model estimated in Table 2., column (4) includes the environmental tax measure and the complimentary measure of renewable energy, with only renewable energy appearing to be significant and negatively signed, suggesting a rise in the use of renewable energy resources produces a fall in the rate of economic growth. This result suggests the use of renewable energy, encouraged through the use of fiscal policy reduced economic growth, as found with other studies that have used general measures of fiscal policy in growth models (Barro, 1991). Alternatively it could

suggest renewable energy resources are subject to the curse of natural resources, much as with non-renewable energy. Investment is positive and significant again, although the workforce variable and initial GDP variables are not significant.

The first model in Table 3, column (5) incorporates other distortionary taxes into the model, to account for the theoretical importance of these taxes to environmental taxes (Goulder 1995). The results suggest that as with other studies, distortionary taxes have a negative effect on economic growth, much as in Kneller *et al.* (1999) and Gordon and Lee (2005), although in this case only labour taxes are significant. When the effects of distortionary taxes are accounted for, environmental taxes relative to GDP also becomes significant, still with a negative effect on economic growth. The coefficient on the environmental taxes is at least twice the size of the other taxes included in the model, indicating they have a more distortionary effect than the other taxes in this model. This underlines the case that there is no double dividend from environmental taxes and they appear to operate in the same way as other distortionary taxes. The coefficient implies that a 1% decrease in environmental taxes as a proportion of GDP is associated with a 0.4% rise in economic growth, whereas a 1% fall in renewable energy as a proportion of total electricity production produces a roughly 0.02% rise in economic growth. The dummy variables for Scandinavian and Transition economies tend to be significant and positive when the other distortionary taxes are added to the model, suggesting both sets of countries have managed increased growth when accounting for environmental policies. However in the case of the transition economies, this may reflect their success in catching up with growth rates in the rest of the EU.

In all tests the renewable energy variable is significant and negative suggesting some form of natural resource curse is evident even with renewable energy, the effect being significant even when other factors are controlled for, as in other studies using non-renewable resources. The results in column (6) in this table exclude the initial GDP variable, as Easterly and Rebelo (1993) and Kneller *et al.* (1999) suggest removing initial GDP can affect the model and therefore acts as a robustness test, although as with the latter study, the result makes very little difference to either environmental taxes or renewable energy. The final two columns re-estimate these two models, but using two-stage-least squares⁸, this approach has been used in many similar studies such as Lee and Gordon (2005). Pollution is used as the instrument for environmental taxes and it is assumed that renewable energy is exogenous. The results suggest little difference, although it has reduced the levels of significance of the tax and energy variables.

IV Conclusion

The results of this study indicate that overall policies to protect the environment and reduce pollution, tend to have a negative economic impact, with little evidence to support the double dividend from the use of environmental taxes. The effect is particularly evident when the model controls for the effects of other distortionary

⁸ These results using instrumental variables need to be treated with some care as two-stage-least squares is a large sample technique, so more weight should be attached to the results from columns (5) and (6). For the same reason we have not attempted to introduce dynamics into the model by using a dynamic panel approach, as suggested by Beck and Levine (2004) in conjunction with growth models, this could be an interesting avenue for future research as more data becomes available. The R^2 statistic is not included as with random effects models it can be misleading.

taxes, particularly labour taxes, as suggested by the theoretical models. It could be that environmental taxes either have the same direct distortionary effect on the economy as other taxes, by reducing the economies competitiveness or that the hoped for reduction in other distortionary taxes following a rise in environmental taxes has not occurred. This could suggest that environmental taxes have been treated as an alternative source of tax revenue rather than as a revenue neutral means of improving the environment.

There is also some evidence that renewable energy has a negative effect on economic growth, which could be due to the current uncompetitive nature of this method of energy generation relative to the use of hydrocarbons. An alternative interpretation could be that this is reflecting the curse of natural resources, whereby the production of renewable energy is dependant on certain natural phenomenon, such as rainfall in the case of hydroelectricity. There is also some evidence that the effects of environmental policies on growth vary across the EU, especially with regard to the transition economies. The policy implications of these results are that whichever means the authorities use to protect the environment, there could be repercussions in terms of lower economic growth. However future studies into this area could measure the effects on economic growth of not reducing greenhouse gas emissions and the study would clearly benefit from a larger dataset, in particular one with a longer time series component, so that the dynamics can also be modelled.

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Table 1. Summary Statistics on Environmental Taxes and Renewable Energy.

	Renewable Energy		Environmental Taxes			
	% total electricity		% GDP		% total tax	
Country	mean	variance	mean	variance	mean	variance
Austria	66.83	60.34	2.37	0.07	5.63	0.32
Belgium	1.83	0.72	1.84	0.00	5.20	1.05
Czech Rep.	4.00	0.21	2.75	0.03	7.79	0.06
Cyprus	0	0	3.01	0.20	9.83	0.80
Denmark	16.80	125.56	5.18	0.43	10.44	1.35
Estonia	0.50	0.28	1.49	0.52	4.64	6.53
Finland	27.47	0.80	3.03	0.01	6.61	2.69
France	14.77	10.70	2.57	0.05	5.90	0.36
Germany	7.33	8.08	2.39	0.00	5.90	0.12
Greece	8.70	1.39	2.77	0.42	8.01	5.49
Hungary	1.83	5.74	2.98	0.01	7.53	0.04
Ireland	5.27	1.92	2.73	0.17	8.56	1.09
Italy	15.00	0.91	3.19	0.16	7.84	1.09
Latvia	47.73	0.42	2.04	0.73	6.85	10.04
Lithuania	3.53	0.10	1.62	0.15	5.55	1.58
Luxembourg	2.76	0.26	2.93	0.01	7.65	0.24
Malta	0	0	3.40	0.06	11.64	2.55
Netherlands	4.50	7.56	3.84	0.04	9.76	0.60
Norway	108.4	14.44	2.39	0.49	5.61	3.04
Poland	2.07	0.52	2.19	0.17	6.50	2.44
Slovakia	17.1	0.52	1.58	1.43	5.06	16.79
Spain	15.00	0.49	2.11	0.02	6.21	0.41
Sweden	52.63	15.04	2.82	0.00	5.58	0.07
United Kingdom	3.00	1.39	2.81	0.09	7.56	0.76

Notes: Source *Eurostat*.

Table 2. Basic Economic Growth Models with Environmental Taxes and Renewable Energy. (Dependent variable is the growth rate of real per capita GDP)

	(1)	(2)	(3)	(4)
Constant	0.140* (6.275)	0.135* (6.882)	0.061* (3.277) 0.158*** (19.275)	0.064* (3.752)
Δk	0.174* (30.942)	0.176* (19.099)	0.899	0.157* (12.065)
Δtwf	0.650 (0.792)	0.610 (0.753)	(1.150) -0.003	0.872 (1.120)
iny	-0.010* (-3.506)	-0.010* (3.516)	(1.250) -0.187	-0.003 (1.074)
Et	-0.395** (1.677)	-0.351 (1.580)	(1.096)	-0.373** (1.667)
Re				-0.016* (3.412)
Scand		-0.004 (0.837)	-0.004 (0.957)	0.003 (1.219)
Trand			0.023* (10.164)	0.023* (9.751)
N	72	72	72	72

Notes: T-statistics in parentheses. The *, ** indicates significance at the 5%, 10% levels of significance. All models include cross section random effects and White cross section standard errors and covariances. Variables as defined in equation (1), with Et and Re being environmental taxes and renewable energy respectively, Scand and Trand are dummy variables for Scandinavian and Transition countries.

Table 3. Economic Growth Models with Distortionary Taxes.

	(5)	(6)	(7)	(8)
Constant	0.043* (3.342)	0.071* (4.749)	0.221 (1.540)	0.605* (2.915)
Δk	0.154* (9.372)	0.157* (12.674)	0.203* (3.075)	0.268* (5.992)
Δtwf	0.423 (0.589)	0.505 (0.740)	0.489 (0.430)	1.049 (0.641)
iny	0.004* (2.292)		0.019* (2.871)	
Et	-0.479* (2.846)	-0.443* (2.714)	-8.45 (1.655)	-15.86* (2.653)
Re	-0.020* (2.712)	-0.018* (2.603)	-0.130** (1.986)	-0.227* (2.992)
Lt	-0.181* (4.710)	-0.136* (3.815)	-0.436* (5.045)	-0.348* (20.802)
Kt	-0.123 (0.594)	-0.071 (0.367)	-0.574 (1.422)	-0.634** (1.660)
Scand	0.014* (4.559)	0.012* (4.611)	0.113** (1.814)	0.195* (2.813)
Trand	0.025* (3.490)	0.008* (2.473)	-0.027 (0.617)	-0.113** (1.860)
N	72	72	72	72

Notes: See Table 2. Instrument used in two stage-least-squares in columns (7) and (8)

is pollution. Variables as defined before, Lt and Kt are labour and capital.